Processing with Lapped Transforms," Artech House (1992) and developed the theory in research papers even earlier. However, counsel and Topiwala showed that the key features that did not appear in any of the three prior art references were "dyadic rational lifting steps."

Each of the three qualifiers is a significant focusing of scope, as well as a departure from the development discussed in the three patents above, as follows. First, the lifting steps here refer to the theory of "lifting" as developed by Wim Sweldens in 1995; see W. Sweldens, "Lifting Scheme: A New Philosophy in Biorthogonal Wavelet Constructions," SPIE Proc., vol. 2569, pp. 68-79, 1995; as well as the first journal paper on it by Sweldens: W. Sweldens, "The Lifting Scheme: A Custom-Design Construction of Biorthogonal Wavelets," Applied and Computational Harmonic Analysis, vol. 3, nr. 2, pp. 186-200, 1996. (Mr. Topiwala gave the Examiner a copy of the latter paper, as well as a document produced by his company, FastVDO, to an international standards body (ITU – International Telecommunications Union): J. Liang et al, "A 16-bit architecture for H.26L, treating DCT transforms and quantization," FastVDO, ITU-VCEG-M16.doc, 30 March 01.) The theory of lifting was already in existence at the time the three patents above were submitted (Malvar: April 2, 1996; Gabriel: April 4, 1997; Hou: Aug. 15, 1997), yet none make any reference to "lifting" or to Wim Sweldens. Applicants therefore submit that none of these authors envisioned a connection between the theory of lapped transforms as developed by Malvar and the theory of lifting as developed by Sweldens. In particular, none envisioned an efficient computational engine using "rational" lifting steps, for performing (new) biorthogonal lapped transforms. Finally, none anticipated the use of "dyadic, rational lifting steps" in the ultra-efficient computation of lapped transforms.

Indeed, all rejected claims refer to lifting steps (either directly or by reference), and all but two (claim 9, and by reference, claim 10) even refer specifically to "dyadic rational lifting steps."

In the interview, Mr. Topiwala pointed out that in customary linear transformation of signals, such as in the computation of lapped orthogonal transforms (LOT) or Discrete Cosine Transforms (DCT), the transformation is performed using a matrix multiplication involving actual sine and cosine values. The transcendental trigonometric functions involved in these transforms have values that are generically floating-point numbers, and therefore the matrix multiplication requires several floating-point multiplications to produce a result. It is well known that floating-point multiplications are very computationally intensive and time consuming, lead to rounding and accumulation errors, require larger buffer memories, and are generally to be avoided, especially in hardware implementations.

The computational method developed by Tran and Topiwala in the instant patent application eliminates multiplications altogether (even non-floating point ones) and reduces the computation to adds and bit-shifts, which are exceedingly simple in hardware implementations. Specifically, as pointed out in the application, page 7, lines 8 through 16, the straightforward trigonometric matrix multiplication can be replaced by three "lifting" steps. Such steps basically produces a time-shifted linear combination of different transform channels. In the current invention, rational fractions with a denominator that is a power of two (and relatively small magnitude integer numerators) are used to approximate the sine and cosine values in the replacement lifting steps. Examples of such fractions given in the application, e.g., page 8, lines 15-16, are 25/16 and 5/4. The beauty of this approach is that the lifting steps do not now even need integer multiplication but can rather be performed by bit shifting combined with addition, which combination of steps is very efficient, especially in hardware. Nowhere in any of the references cited by the Examiner is any reference made to lifting steps, butterfly-structured lifting steps, or to dyadic rational coefficients in lifting steps. We therefore submit that the pending

claims of the current application are quite distinct from, and unanticipated by, the prior art.

Examiner indicated in the summary of the interview that he would conduct an additional search on these features, but in the absence of a newly discovered reference providing these features would in all likelihood allow the Claims at issue. Accordingly, reconsideration and further examination is respectfully requested.

Applicants have made a diligent effort to place the claims in condition for allowance. However, should there remain unresolved issues that require adverse action, it is respectfully requested that the Examiner telephone Frederick C. Williams, Applicants' Attorney at (202) 842-0445 so that such issues may be resolved as expeditiously as possible.

For these reasons, and in view of the above amendments, this application is now considered to be in condition for allowance and such action is earnestly solicited.

Respectfully submitted,

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